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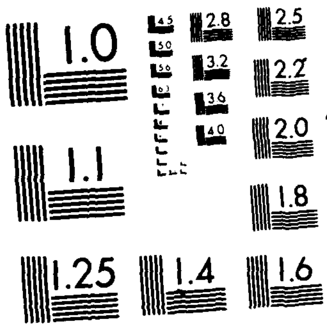

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Final Report

INTEGRATION AND DEMONSTRATION OF THE STAR-I RADAR SYSTEM WITH A REAL TIME SOFT COPY DISPLAY

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JULY 1986

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This report describes three basic tasks. The first task is the definition and implementation of a real-time softcopy display to be used with STAR-1 real-time synthetic aperture radar system. The second task was the all-up system demonstration of the STAR-1, together with the real-time softcopy display. The third task is a data collection for targets of Army interest using the STAR-1 in conjunction with the softcopy display defined and implemented in the first task.

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1
OVERVIEW

The Army has indicated a need to detect, assess and generally locate small isolated targets at sea (small boats) and on land (tanks, trucks and construction equipment). Further, it would be desirable that these missions be performed with substantial area coverage and standoff distances on a 24 hour, all-weather basis, and that the resultant imagery be available on a real-time basis.

Previously, preliminary assessments and data collections were made over the Detroit River and Camp Grayling with the STAR-1 synthetic aperture radar system to ascertain its potential for satisfaction of these Army mission needs (Reference 1). Results were encouraging regarding detectability of targets, but there were deficiencies in the display systems which precluded the display and manipulation of high quality real-time imagery.

This report covers three basic tasks. The first of these tasks is the definition and implementation of a real-time softcopy display system which addresses these deficiencies and is to be used with the STAR-1. Additionally, this report describes a second task, the all-up system demonstration, and a third task, the associated data collection for targets of Army interest using the STAR-1 in conjunction with the softcopy display defined and implemented in the first task.

Since the availability of the STAR-1 was limited to certain specific periods (roughly January through May), critical issues to be resolved included the availability of a soft copy display and the development of an interface with the STAR-1 within severe time

constraints.

As defined by ERIM, the Aydin softcopy display system has the capability to display high quality imagery in scrolling and freeze modes and allows manipulation of imagery to enhance interpretability. A variety of graphics functions are available for special effects (such as annotations or highlighting) and the system can provide mensuration support as well as storage and retrieval of up to twenty images from memory.

The Aydin display can present 1024 pixel elements. Since the STAR-1 swathwidth is comprised of 4096 pixel elements, only one-quarter of the STAR-1 swathwidth can be displayed at full resolution on the Aydin display. Full STAR-1 swathwidth coverage can be displayed on the Aydin by presenting every fourth pixel from the STAR-1.

In view of Army plans to use the STAR-1 and associated ground equipment for a series of remote data collections, it was believed prudent to conduct an all-up system capability demonstration of the STAR-1 and its associated ground equipment (including the Aydin real-time display system) prior to initiation of the remote data collections.

The demonstration was conducted to simulate a routine collection. Predetermined flight paths were flown and their imaged ground swaths were plotted on large scale maps to enable accurate mapping and reporting of any significant returns. The STAR-1 ground station and Aydin display system equipment were positioned to simulate installation in a ground shelter. The equipment was located at ERIM's flight facility at Willow Run Airport. The image analysts and equipment operators followed a pre-defined list of mission operation/exploitation

methodologies. Ground truth photographic coverage was provided as an aid to subsequent interpretation and analysis.

The STAR-1 system and the Aydin display both performed well and satisfied all technical requirements. Although a hardware problem in the Aydin display sustem was not rectified until after the formal demonstration, all capabilities were verified. In addition to real-time monitoring, some post-mission image analysis was conducted by playing back the STAR-1's high density digital tapes (HDDTs). The analysts were able to verify that small targets of interest could be detected, and that the data exploitation methodology was valid. Due to the need to ship the equipment quickly to Lakehurst, New Jersey, no detailed analysis of all of the imagery collected was made. However, a detailed analysis of all of the imagery collected by the STAR-1 over the Michigan area in April and May 1985 will be performed in the near future in order to help determine the full utility and limitations of both the STAR-1 and the Aydin Softcopy Display System.

2
INTRODUCTION

Based on experience gained in data collection with the STAR-1 in 1984 over the Detroit River and Camp Grayling, display system deficiencies and recommendations for their alleviation (Reference 1) were analyzed. These analyses resulted in the identification of basic tasks to be accomplished:

- The development of requirements and specifications governing the purchase of a softcopy display and its ancillary interface allowing it to be integrated with the STAR-1 system.
- The integration of the STAR-1 system with the softcopy display and the subsequent all-up demonstration of overall system performance.
- The collection of data on targets of interest to the Army.

In the performance of these tasks, ERIM developed a detailed specification for a softcopy display system (Appendix C) for performing basic image analysis. In general, the softcopy display system was required to:

- be compatible with the STAR-1 SAR system,
- display high quality imagery in scrolling and freeze modes,
- display imagery in real-time,
- allow manipulation of imagery to enhance interpretability, and
- be completed no later than the week of 21 April 1985.

Based on these requirements, several existing softcopy display systems were evaluated and the Aydin display system was chosen.

ERIM purchased an existing image display system from Aydin for the Army, and detailed the requirements for an interface between the display system and the STAR-1 ground station. The Aydin image display has the system capability for real-time display of collected imagery as well as post-mission playback of all data from HDDT's and certain images stored on an 8-inch floppy disk.

Upon delivery of the display system to ERIM, it was integrated with the STAR-1 ground station and tests were run. A demonstration was conducted to verify the integrated system and to perform necessary calibrations.

The STAR-1 ground station equipment and the Aydin display equipment were physically configured in a field-deployed layout. Two test missions were flown by the STAR-1 aircraft to check out the ground system performance. The missions were flown over pre-established flight lines which imaged the coastal area from Toledo, Ohio to Detroit, Michigan, along the Detroit River, Lake St. Clair and Anchor Bay; and over Fort Custer located near Battle Creek, Michigan. The collections were to acquire imagery over a variety of targets in open water, coastal areas, rivers and on the land.

A month later additional data collections were flown over Ft. Custer to obtain additional data on specific targets of interest to the Army.

The following sections describe the equipment involved, the test missions, and the overall system performance.

3
SYSTEM DEFINITION

Some of the major considerations in the definition of the data collection system included

- Recent advances in SAR technology, allowing radar and image formation functions to be accomplished in real-time.
- Real-time information transfer from radar sensor to user is expected to be of high importance in the missions envisioned by the Army.
- The unique real-time and wide area coverage of the STAR-1, its good image quality, plus its availability and dependability made it an attractive choice for the mission. Additionally, it had demonstrated ability to detect small boats on the Detroit River in collections made in August 1984 (Reference 1).
- Performance and availability evaluations made jointly by the Army and ERIM resulted in the selection of an existing Aydin display system for the softcopy display. Because of their intimate knowledge of their display, Aydin was chosen to design and supply an interface between the Aydin display and the STAR-1 ground station.

3.1 STAR-1 SYSTEM

The STAR-1 (Sea-Ice and Terrain Assessment Radar) system was developed by the Environmental Research Institute of Michigan and INTERA Environmental Consultants Ltd., in early 1982. ERIM performed the system design, development, fabrication, and test of the radar elements and integrated the system elements. INTERA provided the aircraft, the real-time SAR Processor (RTSP) and peripheral equipment, performed the installation of the radar in the aircraft, and presently operates the

radar in the field.

The SAR is a fully-focused sidelooking system which operates at X-band (9.375 GHz). It has a wide swath mode (WS), which covers a swath of 45 km, and a high resolution mode (HR), which covers 22 km. Azimuth resolution is 6 meters in both modes, with range resolutions of 12 meters in the wide swath and 6 meters in the high resolution mode. The system is capable of mapping on either side of the aircraft, 90° from the ground track, with a maximum slant range in the WS mode of 60 km and 40 km in the HR mode.

The SAR is installed in a Cessna 441 Conquest and is flown at a nominal altitude of 10.1 km to provide wide swath coverage and high fuel efficiency. An image is produced in real-time by a digital image formation processing system aboard the aircraft. This image is transmitted to a ground station via a data downlink where a hardcopy is formed on a EDO Western hardcopy recorder. The EDO recorder can output onto dry silver paper or film. The dry silver paper has a very short lag time of about 30 seconds to produce an image on paper. This image, which is of inferior quality, is used to make real-time judgements regarding sensor coverage. When the output is recorded on film, the image quality is much improved, but the film processing takes 20 to 30 minutes after the mission has been completed. The need for high quality, real-time imagery led to the creation of an integrated high quality softcopy display system, though the EDO Western recorder would still act as an auxilary recorder to provide a full scene hardcopy reference product.

3.2 SOFTCOPY DISPLAY SYSTEM

ERIM evaluated a Motorola MTI softcopy display system which was

integrated within an existing Army ground station, but determined that its 32K bps interface rate was too slow to handle the STAR-1 1.4 Mbps imagery data. Various work-arounds were attempted in order to use the system with STAR-1, but without success. ERIM was then requested by the Army to evaluate other existing softcopy display systems. Only systems from Sanders Associates and Aydin Computer Systems indicated promise for meeting performance requirements. Detailed evaluations, including availability considerations, determined that Aydin would best satisfy the requirements.

ERIM generated a detailed system specification for the real-time softcopy display and submitted it to Aydin. Due to the short development time, compromises were made in the requirements and were reflected in the final specification (See Appendix C).

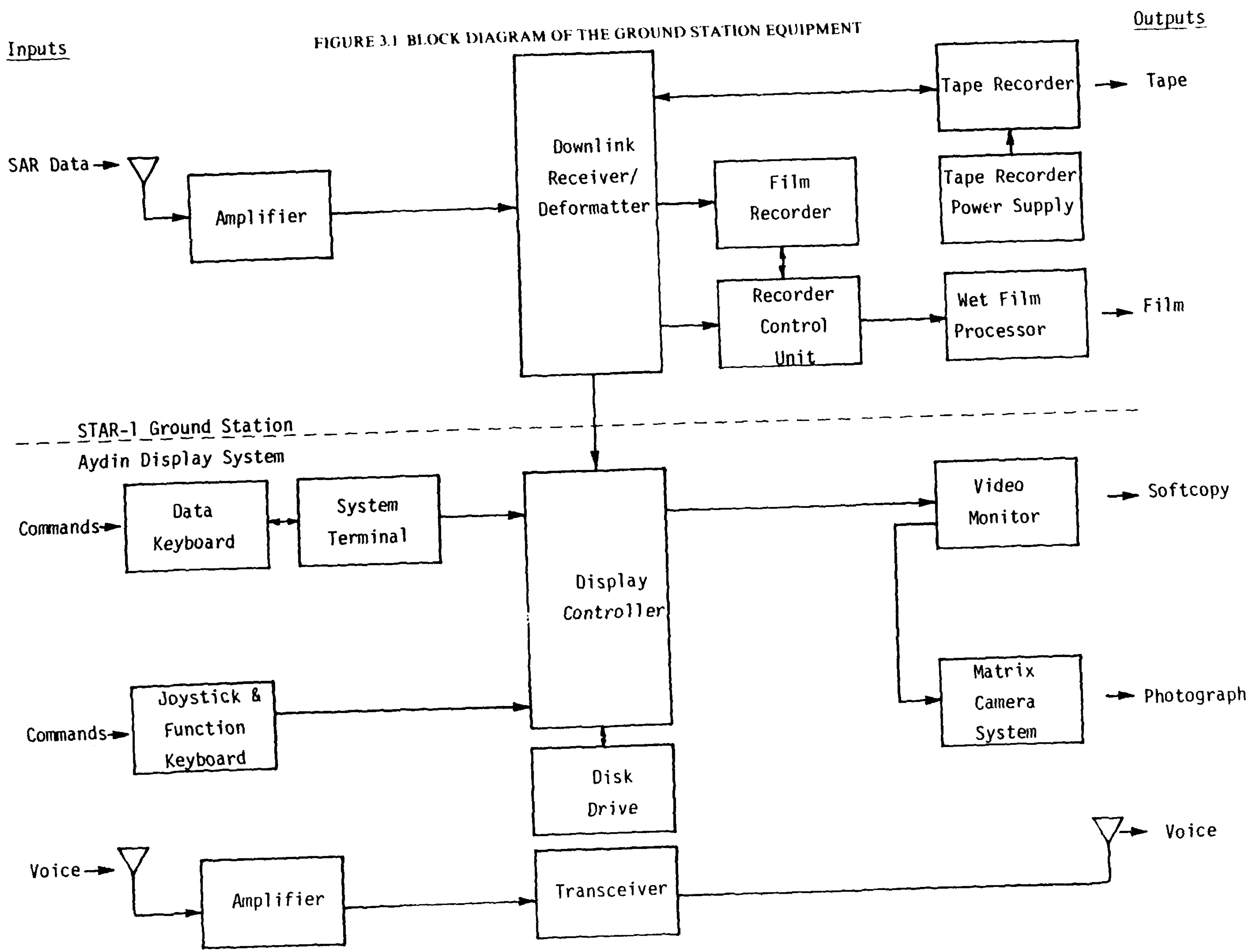
The softcopy display system utilizes a fast scan, high resolution, 19-inch full color monitor capable of displaying two 1024 x 1024 pixel image planes with 8 bits per pixel. The system operates in a scrolling and a freeze mode. During scrolling, the operator can select to observe the full STAR-1 4096 byte swath with every fourth pixel displayed, a half-swath with every other pixel displayed, or a quarter-swath at full resolution. In the freeze mode, the image can be enhanced with magnification and/or roaming through the scene, and through intensity transformations. The system can provide interpixel distances on the image, display histograms, and up to 20 displayed images can be labeled and archived on an internal Winchester disk for later viewing.

To enable the analysts to record the imagery on the monitor, a Matrix Corporation color graphics camera was added to produce 4" x 5" or 8" x 10" Polaroid hardcopies of the display monitor.

3.3 SYSTEM INTEGRATION

Integration of the Aydin softcopy display with the actual STAR-1 ground station and with the Matrix camera system occurred at ERIM's Willow Run Airport facility on April 24th. ERIM and INTERA personnel, along with representatives from both Aydin and Matrix, were in attendance. Matrix calibrated their camera system to the video output from the softcopy display. Aydin integrated the display controller to the STAR-1 downlink receiver. A block diagram of the ground station equipment is shown in Figure 3.1. A more detailed description of the STAR-1 Softcopy Display Development task is given in Reference 2.

FIGURE 3.1 BLOCK DIAGRAM OF THE GROUND STATION EQUIPMENT



4
APRIL 1985 TEST DEMONSTRATION

In order to provide an overall check on the integration and performance of the STAR-1 radar system with the Aydin display system, test missions were designed and flown during April 1985 to provide real-time SAR data on target areas of interest. The ground station equipment was located at the ERIM facility at Willow Run Airport.

4.1 MISSION PLANNING

Test missions were planned to image target areas simulating typical mission areas. These areas included five flight lines that would image coastal regions, of varying population density, containing many small streams and bays, large and small rivers, and with some commercial and small boat traffic. A sixth flight line was designed to image in-land areas which contained several arrays of military vehicles. In particular, the flight lines were located to image 1) the coastal area between Toledo, Ohio and Detroit, Michigan; 2 and 3) the entire Detroit River; 4) the coastline above Detroit on Lake St. Clair; 5) Selfridge AFB and the Clinton River, easterly across Anchor Bay past the St. Clair River into Canada; and 6) Ft. Custer and the Battle Creek, Michigan area.

The only area imaged where targets had been pre-positioned was at Fort Custer. A total of 26 military vehicles were placed along three parallel roads to simulate convoys, and another eight vehicles were placed in two open field arrays (Figures A.5 and A.6).

4.1.1 FLIGHT SCHEDULE

Each flight line was flown at least one time about 10:00 a.m. on the morning of 25 April and then again at 4:00 p.m. during the afternoon of the 25th, with the exception of Fort Custer. Fort Custer was imaged on several passes with North and South look directions on the morning of 25 April only, since a static display of military equipment was the prime target of interest. An earlier flight was planned for the 24th, but was cancelled due to severe weather conditions.

4.2 SYSTEM LAYOUT

The equipment at the ground station was situated on two tables in a manner to simulate a possible field deployed mobile unit, and to allow easy access to the rear of each piece of equipment to make necessary connections. Flight line reference maps were adjacent to the display (see Figure 4.1, Ground Station photo).

The Aydin softcopy display consisted of 1) a CPU (display controller); 2) a high resolution 1024 x 1024 pixel 19-inch color video monitor; 3) an interfacing control data keyboard and terminal; 4) an 8-inch floppy disk drive; 5) a graphics control keyboard with joysticks, and 6) the Matrix camera system. (See Figure 4.2, Softcopy Display Station photo.)

4.3 DATA EXPLOITATION METHODOLOGY

To properly exploit and analyze the data collected during each mission, an exploitation plan was established. The plan was divided into three areas of pre-mission, mission, and post-mission

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FIGURE 4.1 GROUND STATION PHOTO

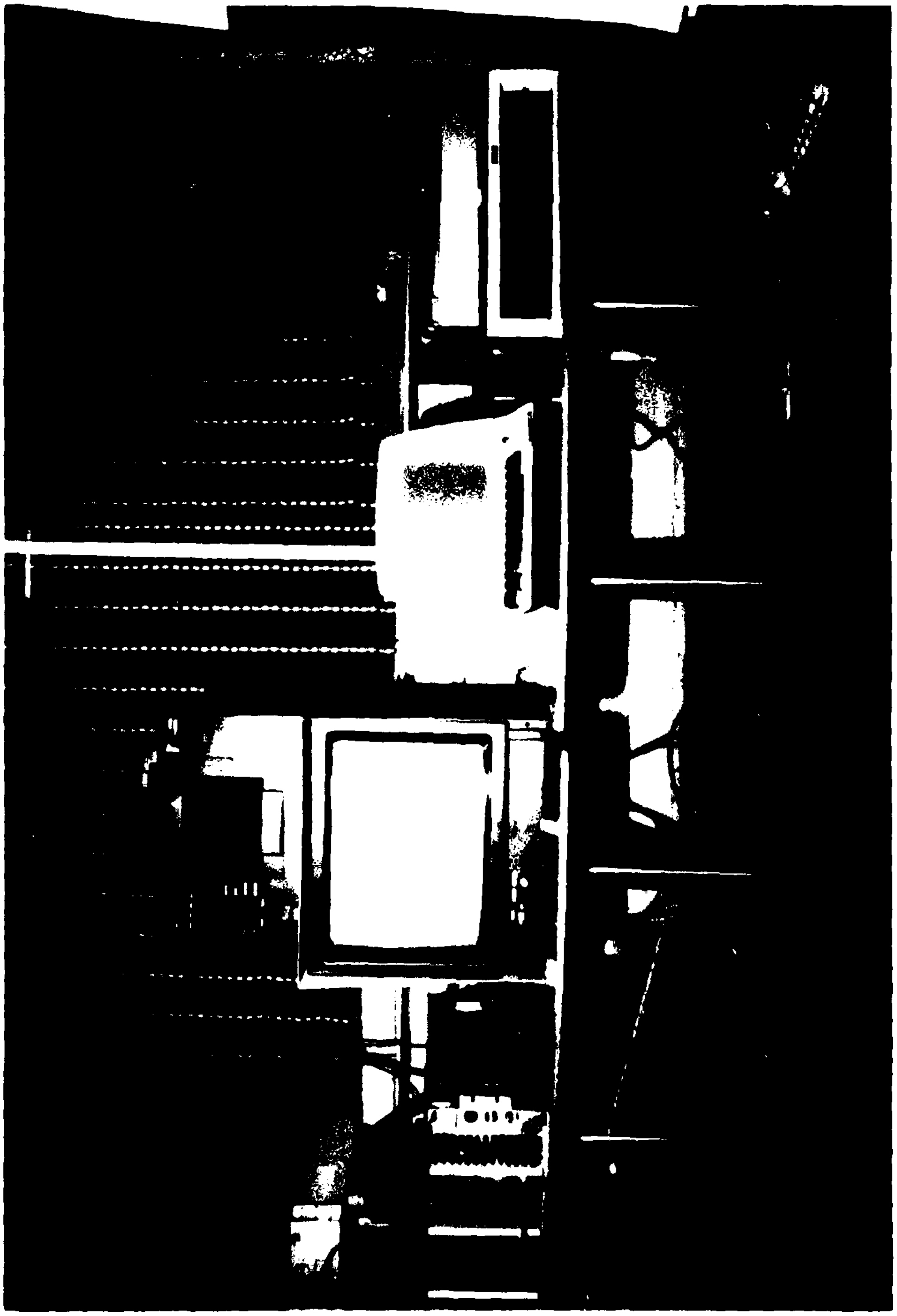

FIGURE 4.2 SOFTCOPY DISPLAY STATION PHOTO

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planning/analysis. The original plan was designed for a proposed future collection and used here to check its practicality and to provide a dry run for the test crew.

4.3.1 PRE-MISSION PLANNING

A large part of the pre-mission planning involved assembling all of the support equipment and supplies which would be necessary for a collection and exploitation mission at a remote location. For the proposed future collection, the list was quite extensive, since the mission location was in an area which precluded additional on-site support or refurbishing of supplies. The important pre-mission assignments were to:

1. Acquire adequate maps of the collection areas.
2. Establish flight lines and flight schedules to acquire desired surface coverage, meet pre-defined objectives, and allow for change between or during flights.
3. Make overlays for maps to record significant radar returns, to plot coordinates, and for monitoring change detection.
4. Have analysts familiarize themselves with the target areas, normal objects and patterns present, identifying terrain features, etc., through the use of collateral information.
5. Devise a data analysis and reporting scheme.
6. Have log sheets available for recording of information and other pertinent data.
7. Make a work schedule and manning plan for the crews involved.
8. Identify significant areas or targets of interest from previous flight for analysts to focus upon in the next flight.
9. Assure ground station, display system and support

equipment are all working properly and prepared for upcoming collections.

10. Establish ground truth sufficient for subsequent interpretation and analysis.

4.3.2 MISSION ANALYSIS

During a collection, there are specific responsibilities for each member of the crew. The image analysts must monitor the softcopy display screen and analyze the imagery as it is collected. They have the option of freezing an image or letting it scroll. The analysts must also 1) keep a flight log (start/stop time for each flight segment, coordinates, etc.); 2) record any significant returns on appropriate forms and plot them on the corresponding map overlay; 3) monitor previous significant returns or high interest target areas; 4) report significant activity through proper channels as required by the sponsor; and 5) maintain contact with the STAR-1 pilot to coordinate in-flight schedule/pattern changes (i.e., immediate flight segment retasking).

The support crew must maintain the STAR-1 ground station, Aydin display system, and all support equipment. They operate and monitor the HDDT recorder and the EDO Western hardcopy recorder, and provide assistance to the analysts when necessary.

4.3.3 POST-MISSION ANALYSIS/PLANNING

After each mission is completed, the analysts must conduct a detailed analysis of the entire mission. The wet film from the EDO recorder is processed. All significant returns must be 1) examined to attempt identification, 2) recorded in the log book with coordinates and description, and 3) plotted on the appropriate map overlay. Image manipulation of important targets also will extract more information

about each target. Image or scene comparisons can also be made of the same target areas from previous collections to detect or verify changes.

A mission summary report is made which lists 1) all significant returns and activity, 2) change detection, 3) mission performance (such as usable coverage, mission duration, etc.), and 4) important areas to monitor on the following mission. The log sheets, maps and records are organized and stored, and any necessary preparations are made for the next mission (such as equipment repair, scheduling of flight lines, arrangement of key notes corresponding to each proposed flight line, etc.

4.4 AERIAL PHOTO GROUND TRUTH

To enable the image analysts to accurately verify their SAR image reports, black and white aerial photography was collected over the image areas coincident with the STAR-1 SAR coverage. The aerial photos were taken not only to supply "ground truth", but to enable future, more detailed analysis of the STAR-1 SAR and softcopy display utility from an information extraction point of view. The exposed film from each mission was flown directly to Willow Run Airport and then delivered to ERIM's photo laboratories in Ann Arbor for immediate processing. The rapid turn-around was specified to enable the image analysts to quickly verify their responses and to better understand the STAR-1 and Aydin display capabilities prior to their planned departure.

5
RESULTS

The integration of the Aydin softcopy display with the STAR-1 ground station was successfully accomplished. However, due to hardware problems encountered during the formal demonstration, real-time data analysis was not possible.

5.1 SYSTEM INTEGRATION

Integration of the Aydin softcopy display with the STAR-1 ground station and with the Matrix camera system occurred at ERIM's Willow Run Airport facility. Both Aydin and Matrix personnel were in attendance. Matrix calibrated their camera system to the video output from the softcopy display and Aydin integrated their display controller to the STAR-1 downlink receiver. A problem with the display system was apparent when a HDDT was played into the Aydin monitor and two overlaid images were displayed. Troubleshooting determined that the two RAM chips were being simultaneously addressed and two images, separated by one-half swath, were being overlaid. The problem was corrected by rewiring the chips, but the system did not operate properly until after the final STAR-1 test flight scheduled for April 1985 was completed.

5.2 DATA EXPLOITATION

The hardware problems encountered with the Aydin softcopy display prevented analysis of the SAR imagery in real-time. However, by playing back the STAR-1 HDDT's recorded during each mission, the analysts were able to successfully check the validity of using their pre-defined data exploitation methodology and, at the same time, verify the detection of

targets (Figures A.2, A.3, A.4, A.9, and A.12). A detailed analysis of the STAR-1 radar imagery and of the Aydin display utility/capability could not be performed however, due to a lack of time before the equipment was packaged for shipping.

6
STAR-1 MAY 1985 DATA COLLECTION, FORT CUSTER

It was the original intent of the Army to use the STAR-1 and associated ground equipment for a series of remote data collections scheduled for May 1985. Due to Army inability to obtain the requisite deployment order for these collections, it was determined that an alternate series of missions for the STAR-1 would be flown. Accordingly, plans were established to fly the STAR-1 over a set of targets at Fort Custer. These flights were made at various aspect angles and various grazing angles. Particular emphasis was placed on obtaining the aspect and grazing angle data at low grazing angles due to the dearth of data in this region. Data obtained from these flights was recorded on High Density Digital Tapes (HDDT) using the STAR-1 onboard recorder (the ground equipment, being in transit, was unavailable for use in conjunction with these flights).

Data collected during the May flights was generally very satisfactory. The STAR-1 experienced moderate-to-severe turbulence on certain portions of the low altitude runs (low grazing angles) which occasioned image blurring on portions of the imagery collected during these runs. Sufficient imagery free from blurring was available to allow image interpretation and analysis to proceed.

7
RECOMMENDATIONS

In order to more fully determine the utility and benefit of a softcopy display integrated with the STAR-1, an actual series of data collections with real-time data analyses should be conducted over a specified area for a period of at least one week. This would enable the analysts to become familiar and comfortable with the operation of the display system, as well as identifying and monitoring the designated target area(s). Within this period, the data exploitation methodology could also be refined to increase effectiveness.

Though only limited "hands-on" exposure to the softcopy display system was possible during the test demonstration, the high quality real-time image display capability (demonstrated post-mission with HDDT's) proved to have high potential value. The only apparent major shortcoming of the display station was the loss of "scrolling information" when the freeze-frame mode was in use. Each time a scrolling scene was frozen for further data manipulation, and/or to enable a more detailed image analysis, much real-time data was lost. This excessive real-time data loss could be attributed to several areas, from man-machine interface to hardware and software limitations. Several recommendations to alleviate the problem are listed below:

1. Have two monitors in the display station, one dedicated to scrolling and the other available for simultaneous freezing of images. This would also hasten post-mission detailed image analyses, and mission reporting time. It is also possible to have the displays operate on alternate strip frame areas.
2. Simplify the user interface by using function keys, and/or by selecting data manipulation parameters

from a menu versus searching for them and typing each one in by hand.

3. Have the monitor, or one of the two monitors proposed, display in monochrome instead of color, since the monochrome display is more conducive to interpretability. If only a single monitor is to be used, a study needs to be conducted to compare the benefits of using a color monitor rather than a monochrome, and vice versa, and the results reflected in the system specification. One drawback to using only a monochrome monitor is that the current graphics display capabilities would be reduced.

4. Develop additional intensity transformation software to aid in the image enhancement process, allowing for improved image interpretability.

5. Use the newly-developed ERIM Broad Area Display algorithm in conjunction with the softcopy display. The algorithm allows a full swath display by utilizing spatial compression techniques to retain a large portion of essential target information. The current full swath capability displays only every fourth pixel, thus reducing the likelihood of detecting small vessels or targets. Additional viewing time for interpretation is allowed through the use of the Broad Area Display algorithm, the increase in viewing time being proportional to the degree of spatial compression chosen.

6. Structure the subsequent interpretation and analysis of data gathered by the STAR-1 during the April 1985 all-up system demonstration and the May 1985 collection at Ft. Custer to accommodate initial real-time image exploitation experiments. These experiments could generate information leading to additional insight regarding the parameters governing the real-time image exploitation process.

Since the data gathered at Ft. Custer (May 1985) includes not only targets and backgrounds of interest to the Army but also includes flight lines for these targets at low grazing angles (10^o, 8^o, 6^o, 4^o, 2^o, 1^o) particular attention should be given the low grazing angle data. It

could provide an initial information source for Army determination of SAR utility at long ranges and an initial source for training imagery.

REFERENCES

1. Final Technical Report, "Initial STAR-1 Utility Demonstration for the Army (1984) Task I, Subtask V" by R.F. Nalepka, ERIM Report 178000-4-F.

2. ERIM memorandum SED-85-147, dated 8 May 1985, titled "Final Technical Report - STAR-1 Softcopy Display Development Task," by P.R. Lumley.

APPENDIX A

This Appendix contains sample SAR imagery collected with the STAR-1 radar during April and May 1985. The flight profile for each image is shown in Figure A.1.

Image No.	Date	Altitude (ft)	Heading (deg)	Look Direction	Depression Angle (deg)
A.2	25 Apr 85	24,000	240	L	12
A.3	25 Apr 85	24,000	240	R	12
A.4	25 Apr 85	24,000	240	R	12
A.9	20 May 85	33,000	180	L	15
A.12	20 May 85	8,000	360	L	4

FIGURE A.1 FLIGHT PROFILES

Figure A.2

Figure A.2 is of the Lake Erie/Toledo, Ohio area. Prominent visible features in this image are:

1. Rail yard near mouth of river.
2. Two (2) bridges over river.
3. POL storage areas near rail yard.
4. Numerous small craft in river/lake.

This image is approximately 2048 pixels across and 2600 pixels along-track. This gives approximately 27,000 ft by 49,000 ft coverage.

Figure A.3

Figure A.3 is of the Battle Creek, Michigan/Ft. Custer area. Prominent visible features in this image are:

1. Kellogg Regional Airport.
2. Ft. Custer military reservation (image center)
3. Several small rivers.
4. Several major roads and bridges.
5. Several urbanized areas.
6. Several small lakes.

This image is 4096 pixels across and 5000 pixels along-track. This means this image covers approximately 56,000 ft cross-track and 95,000 ft along-track.

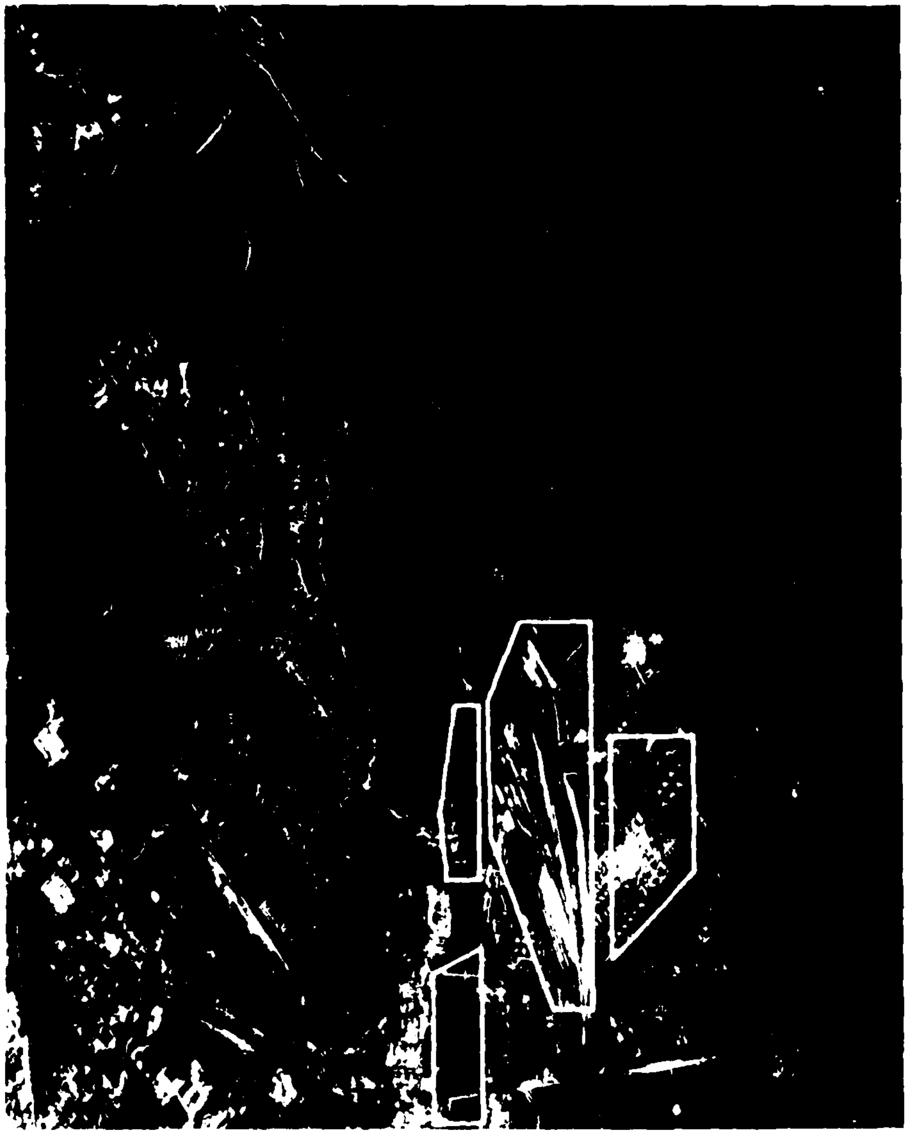

FIGURE A-2 25 APRIL 1985

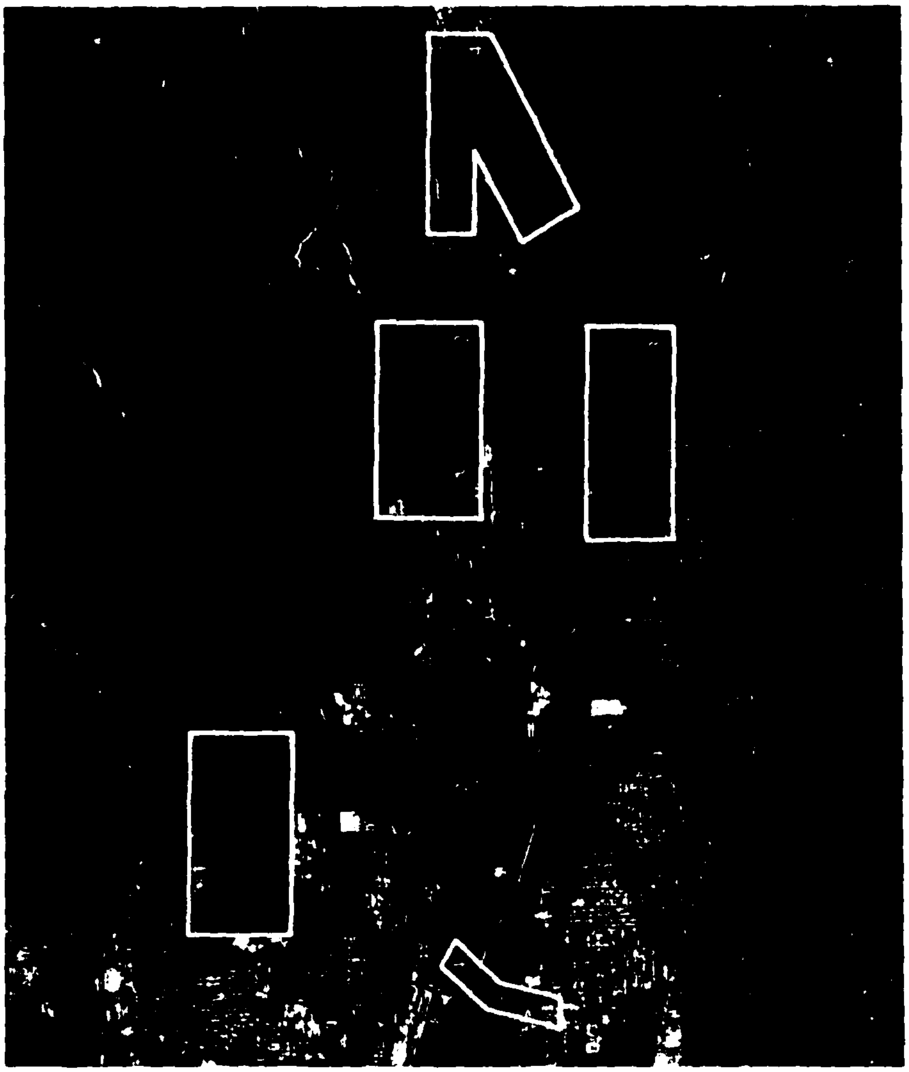

FIGURE A-3 FORT CUSTER AND ENVIRONS 25 APRIL 1985

Figure A.4

Figure A.4 is an enlargement of the Ft. Custer military reservation depicted in Figure A.3, Subimage 2. Prominent visible features in this image are:

1. Ft. Custer military reservation.
2. Military motor pool.
3. Multiple convoys.
4. Post area.

Ground truth for the convoys and motor pool area can be seen in Figure A.5 and Figure A.6. Features in the vicinity of the Ft. Custer post area can be located using Figures A.7 and Figure A.8.

Figure A.9

Figure A.9 is of the Ft. Custer military reservation. Prominent visible features in this image are:

1. Ft. Custer military reservation.
2. Military motor pool.
3. Multiple convoys.
4. Post area.

Ground truth for this image can be seen in Figure A.10 and Figure A.11. Grazing angle is 15°.

Figure A.12

Same scene and ground truth as Figure A.9. Grazing angle is 4°.

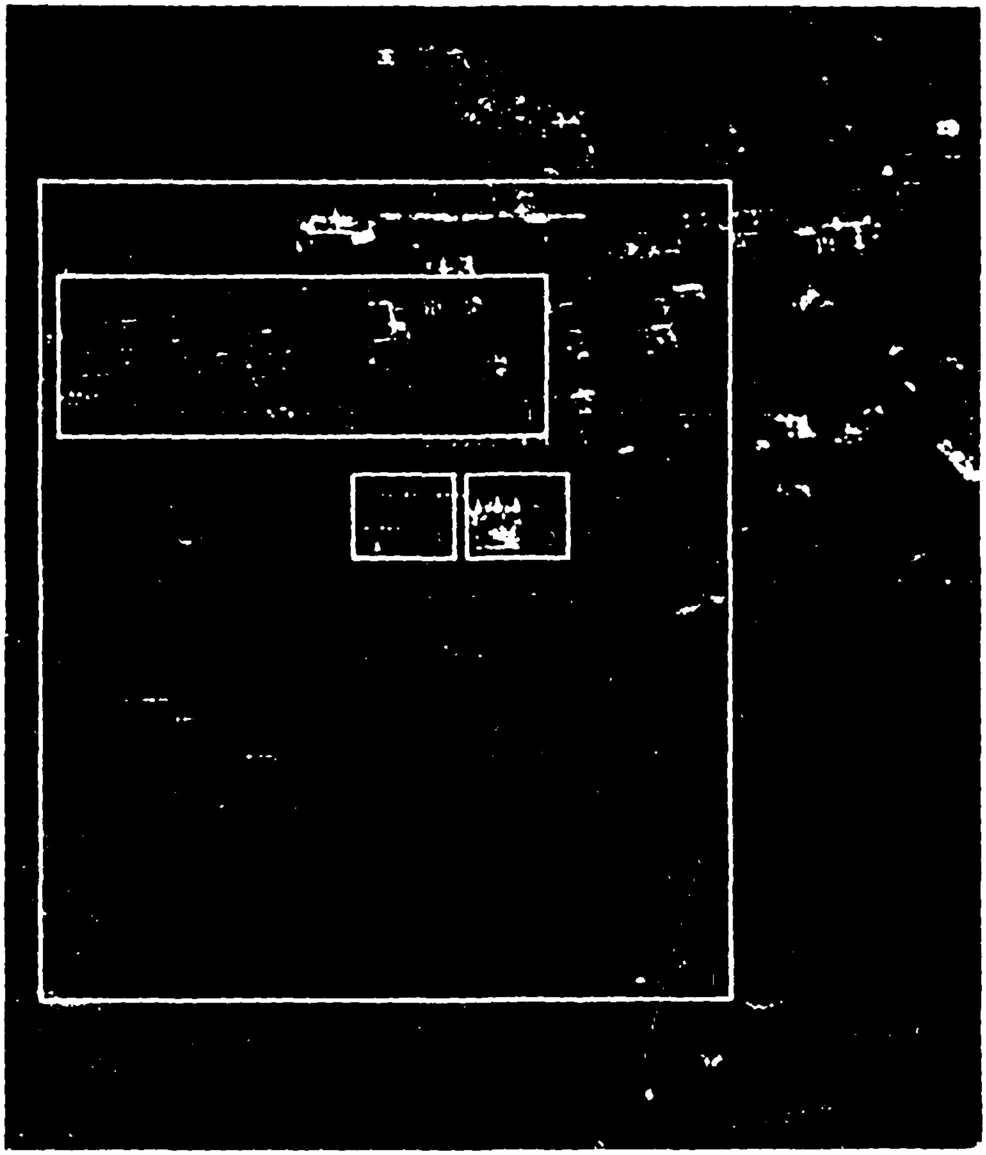

FIGURE A-4 FORT CUSTER VEHICLE ARRAY 25 APRIL 1985

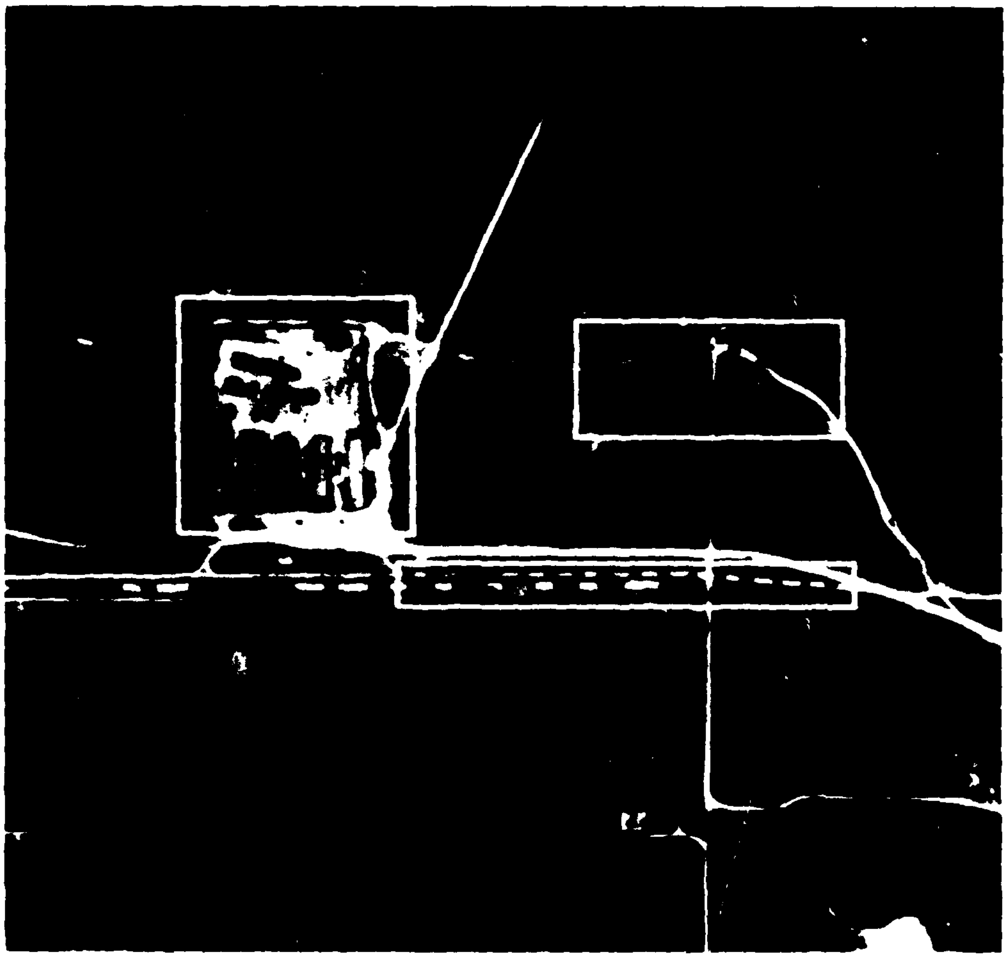

FIGURE A.6 FORT CUSTER VEHICLE ARRAY 25 APRIL 1985

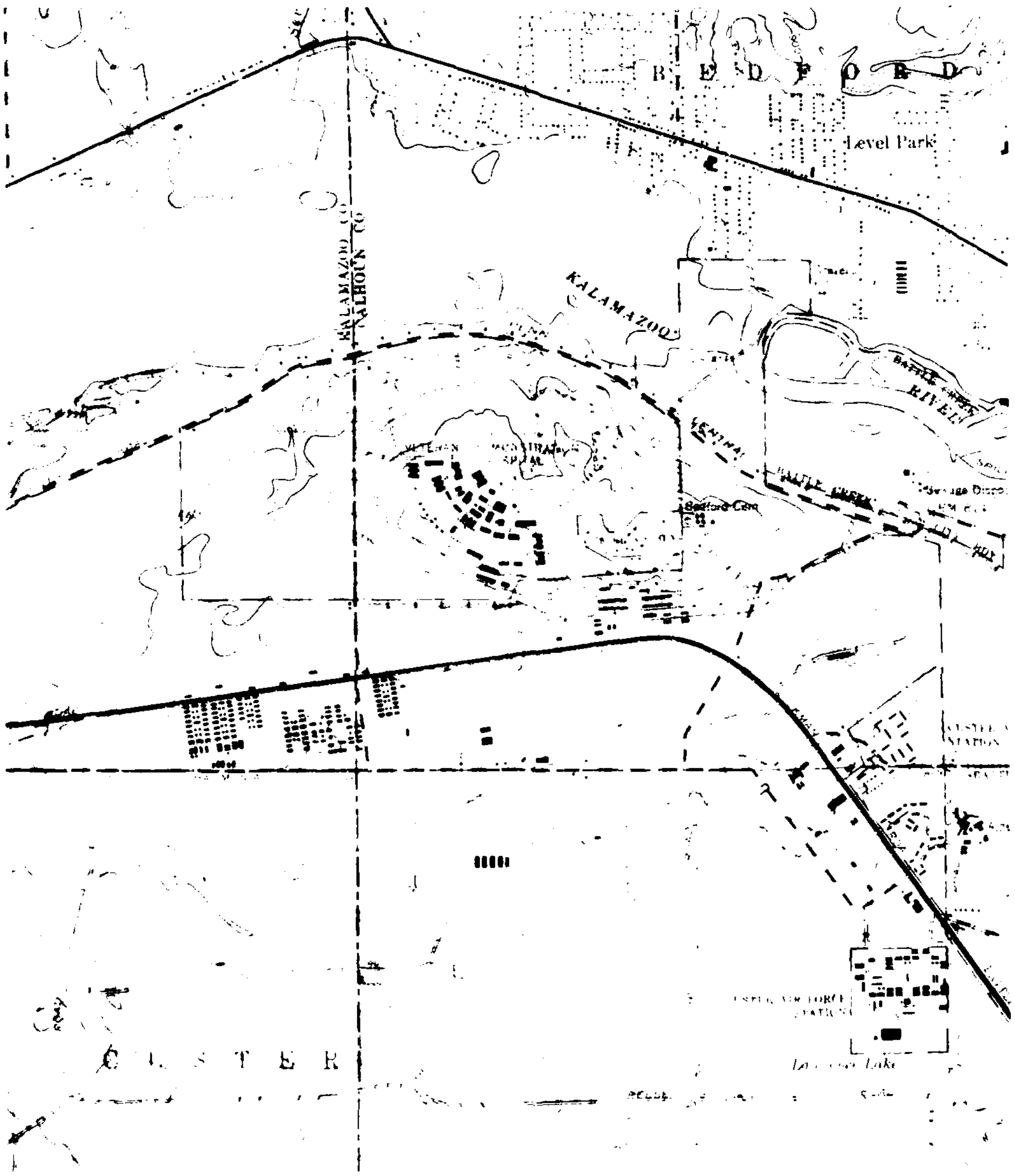

FIGURE A.7 FORT CUSTER AND ENVIRONS

86-819

FIGURE A.8 FORT CUSTER AND SURROUNDING AREA 25 APRIL 1985

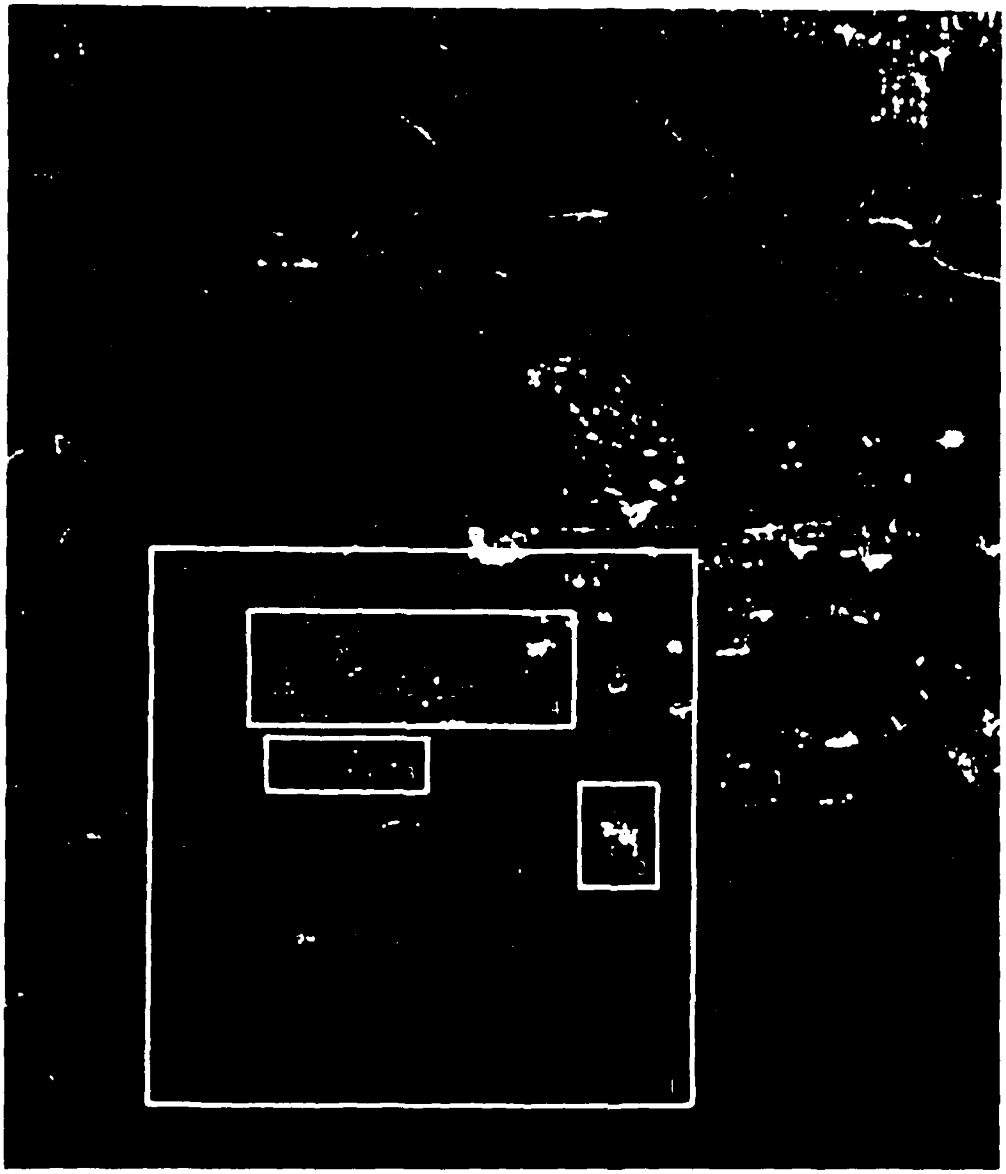

FIGURE A-9 FORT CUSTER VEHICLE ARRAY 20 MAY 1985

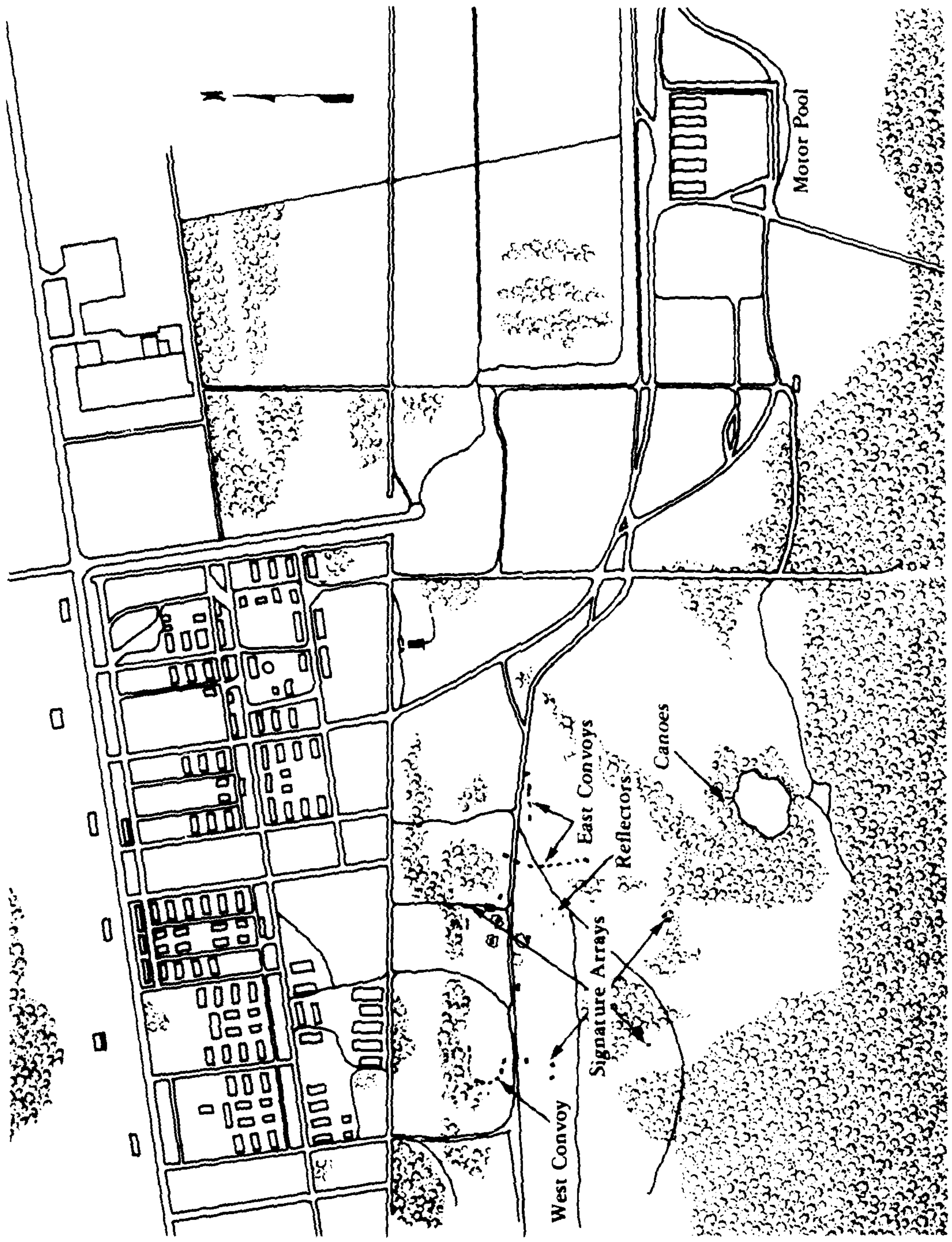

FIGURE A.10 FORT CUSTER SITE CONFIGURATION, 20 MAY 1985

86 681 Rev 2

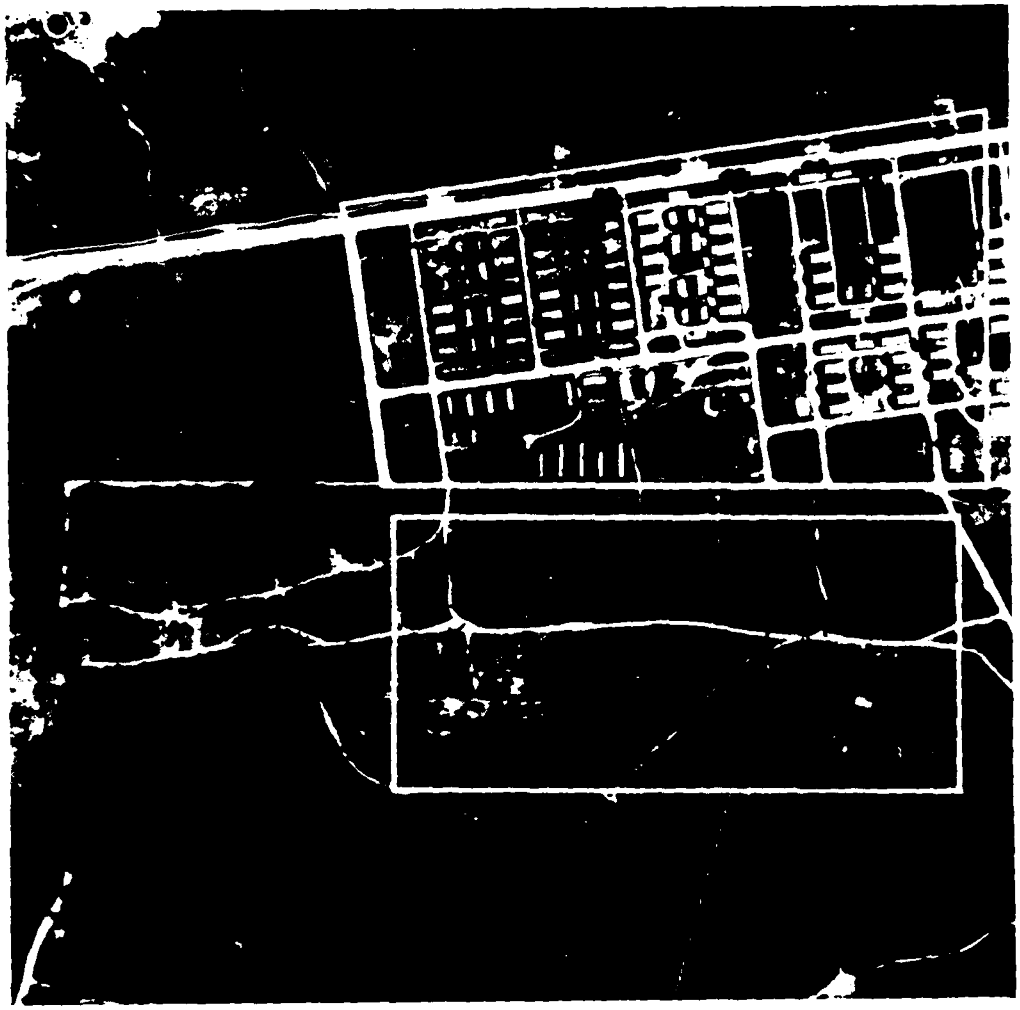

FIGURE A.11 FORT CUSTER VEHICLE ARRAY AND BARRACKS AREA 20 MAY 1985

86 68'

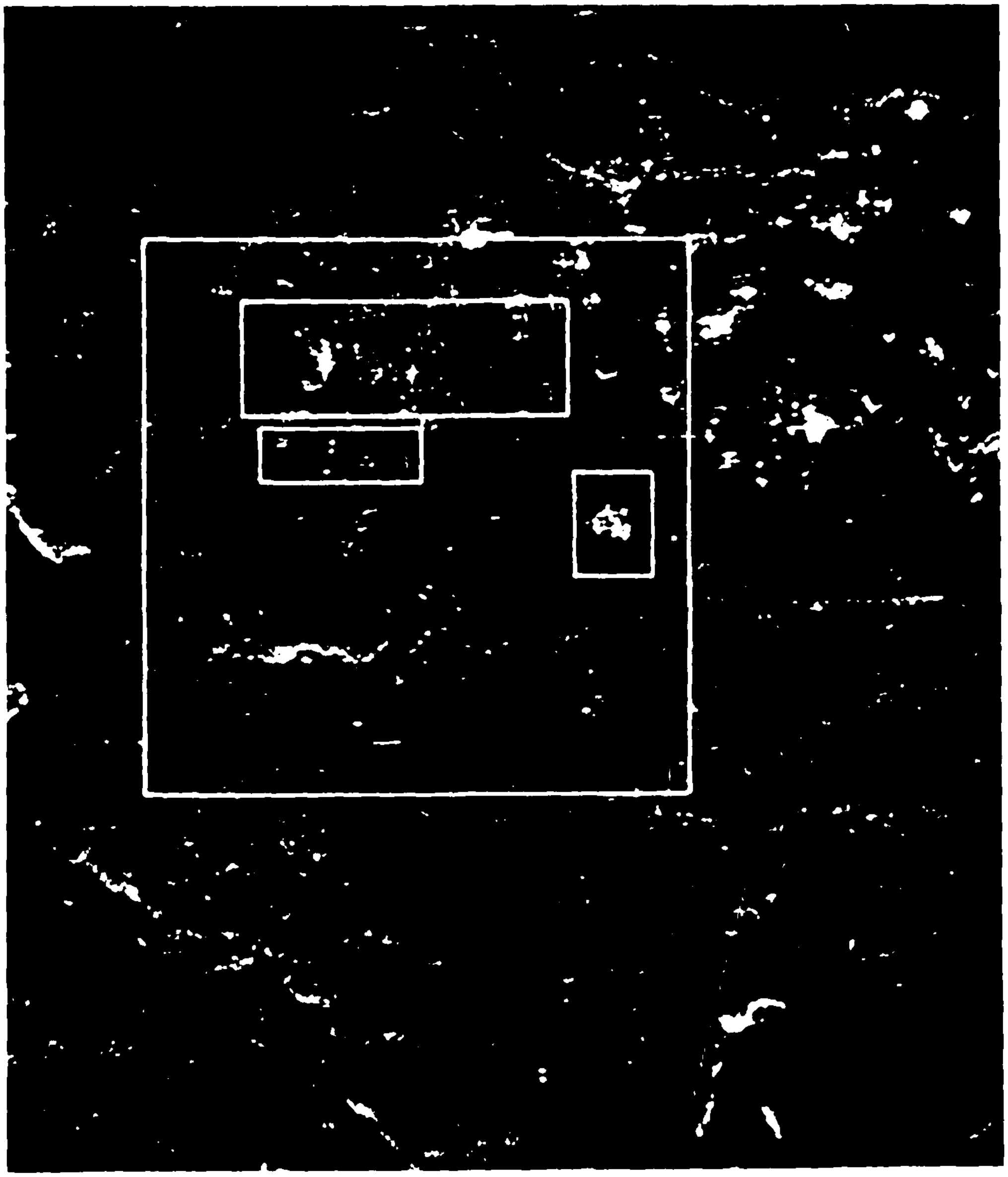

FIGURE A.12 FORT CUSTER VEHICLE ARRAY 20 MAY 1985

86-818

APPENDIX B

This Appendix contains STAR-1 flight logs for the 25 April 1985 and 20 May 1985 data collections.

1st Flight

STAR 1 FLIGHT LOG

DATE: 25 April/85 FLIGHT: Antares Test ERIM Willow Run

TAKE OFF TIME: Willow Run 13:15 (GMT)
LANDING TIME: 1700 (GMT)
ELAPSED TIME: 3.8 HRS.

INS START POSITION: 42142 N 81327 W
INS STOP POSITION:
POSITION ERROR: 1 mile Nmi
POST FLIGHT INS GRND SPEED: 1 Kts.
TX INCIDENT POWER: -5.0 dBm
TX REFLECTED POWER: dB

TWT METER: 1870 HRS.

DEPARTURE LOCATION: ERIM Willow Run
ARRIVAL LOCATION: ERIm Willow Run

HDDT #: REAL TIME #:

DOWNLINK LOCATION: ERIM Willow Run

MISSION PROFILE:

AIRCRAFT WAYPOINTS:

1	1	S	4115N	83386W	4200N	8247W	L
1	2	S	4140N	82477W	42218	8245W	L
1	3	S	4213	8230	4200	8315W	R
1	4	S	4215	8234	4245	8230	L
1	5	W	42197	8300	42237	8215	L
1	5	E	42342	8500	42342	8530	L
1	7	W	42052	8530	42052	8500	L
1	8	W	42002	85000	4200	8530	R

MISSION SUMMARY: 11 - 17 hi res 26K

1 8 test Modiak

SPONSOR: ERIM

AUTHORIZATION: Carl Gates

FLIGHT CREW: Garry Sanderson
Steve Leung
Tom Usagramte

STAR 1 SYSTEM

STAR I NAVIGATION LOG DATE: 25 Ap/85 HDDI# One 25 Ap/85 PAGE 1 OF 2

OPERATOR:

	MARK	LINE	GMT TIME	POSITION LAT	POSITION LONG	HEAD	ALT	GRND SPEED	LOOK	HDDT TRK	HDDT FOOTAGE	RANG DELAY	COMMENTS
P 1	1	GW	1345	42342	85000	270	24K	206	L	1	0000	16	Delay change to 16 due to height
Bad line	2											17	Range delay change(MDA config at 17 km)
	3			42052	850300					1	2000	17	will repeat 16W
P2 aborted wrong look directions													
P2 5		6	1415	42052	850300	180	24K	306	R	1	2500	16	Repeat 16E look R config. ok
	6		1418	42342	8500						3800	16	End of line (bad line A/P off)
P 3	7	7W	1428	42082	85000	270	24K	216	R	1	3800	16	Recorder was not on!
	8	7W	1430	42082	85300						3800		End of line 7
P 4	9	8E	1437	42002	85250	270	24K	310	L	1	3800	16	Damping at 10
	10		1441	4200	8530						5800		End of line 8
P 5	11	7W	1447	42082	85000	270	24K	216	R	1	5800	16	Repeat of 17
	12		1450	42082	85200						6700		end of 1 7
P 6	13	1 1	1511	41300	83216	040	24K	240	L	1	6700	16	1 1
	14		1520	4153.1	82550					2	8600		End of 1 1 HD DR SW track

Line 6 & 7 & 8 were Custer

STAR I NAVIGATION LOG DATE: 25 April/85 HDDT# one PAGE 2 OF 2

	MARK	LINE	GMT TIME	POSITION LAT	POSITION LONG	HEAD	ALT	GRND SPEED	LOOK	HDDT TRK	HDDT FOOTAGE	RANG DELAY	OPERATOR SL COMMENTS
P7	15	12N	1528	4100	8247.4	003	24K	208	L	2	8700	16	Start 12, all water
			1535	4215	8245.5					2	6200		end
P8	17	13W	1542	4211	82370	270	24K	237	R	2	6200	16	L3W
	18			4204.4	83000					2	4900		end
P9	19	L4N	1555	4210	8234.7	006	24K	214	L	2	4900	16	L4 check att knob now set ok to 38
	01		1600	4233	8231.6					2	2900		should tighten screws
P10	02	L5	1612	42231	82220	263	24K	220	R	2	2900	16	L5W
	03		1618	42207	82490							16	end
P11		L9	1620			263	24K	215	L	2	1000	16	L9 wide swath 30dB 7 looks
			1626							3	700		transit track objects T3F

STAR I-X

STAR 1 **RADAR LOG** DATE: 25 April/85 PAGE 1 OF 1

OPERATOR: S. Leung

MARK	LINE	GMT TIME	ANT ELEV	RX ATTEN	RMS VIDEO	RTP Swath MOD	RTP Swath SIZE	RTP Swath SUB	LUT INT	LUT STC	GRND CONV	RTP GAIN	RTP LOOKS	COMMENTS
1	6W	1345	11.1	42	09	full	N	-	0	0	off	2	4 2345	difficult in config, took go wire off
5	6E	1415	10.5	42	10	N	full	-	0	0	off	2	4 2345	may be poor line A/P
7	7W	1428	10.3	42	6	N	full	-	0	0	off	2	4 2345	HDDR not on
9	8E	1437	10.3	42	10	N	full	-	0	0	off	2	4 2345	L8
11	7W	1447	10.3	42	10	N	full	-	0	0	off	2	4 2345	repeat L 7
13	1	1510	10.3	42	10	N	full	-	0	0	off	2	4 2345	L 1
15	2	1528	10.3	40	0	N	full	-	0	0	off	2	4 2345	L2 att knob feel like slipped
17	3	1542	10.3	40	10	N	full	-	0	0	off	2	4 2345	L3 check knob OK should tighten more
19	4	1555	10.3	38	13	N	full	-	0	0	off	2	4 2345	L4N
		1612	10.3	38	13	N	full	-	0	0	off	2	4 2345	L5W
			7.5	30	12	W	full		0	2	on	1	all	L 9 wide transit

2nd Flight

STAR 1 FLIGHT LOG

DATE: 25 April 1985 FLIGHT: ANTARES ERIM Demo

TAKE OFF TIME 19=18 (GMT)
LANDING TIME 21.55 (GMT)
ELAPSED TIME 2.2 HRS.

INS START POSITION
INS STOP POSITION Nml
POSITION ERROR Kts.
POST FLIGHT INS GRND SPEED dB
TX INCIDENT POWER dB
TX REFLECTED POWER
HRS.
TWT METER

DEPARTURE LOCATION: Willow Run - ERIM
ARRIVAL LOCATION: Willow Run - ERIM
HDDT #: April 25/2 REAL TIME #:
DOWNLINK LOCATION: Willow Run

MISSION PROFILE:

AIRCRAFT WAYPOINTS:

L1	411583386	4200	8247	L
L2	414582477	42218	8245	L
L3	4210282400	8305042044 R		L
L4				L
L5				

MISSION SUMMARY:
Repeat of early flight over Lake St. Clair

SPONSOR:
AUTHORIZATION:
FLIGHT CREW: Garry Sanderson
S. Leung
Carl Gates

STAR 1 DOWNLINK LOG   DATE: 25 April 85   HDDT# 2 Ap/85   PAGE 1 OF

OPERATOR: S. Leung

	MARK	LINE	GMT TIME	POSITION		HEAD	ALT	GRND SPEED	LOOK	HDDT #2		RANG DELAY	COMMENTS
				LAT	LONG					TRK	FOOTAGE		
P1	1	1	20.10	4125	83273	041	25K	260	L	1	0000	17	L 1 NE
	2	2	2017	41503	82552						2450		end of L1
P2	3	2	2023	41502	82472	003	25K	233	L	1	2450	17	L2 start over water
	4	2	2030	4215	82455						4700		
P3	5	3	2037	4210.2	82400	249	25K	241.1	R	1	4700	17	L3 ¼ SW 3 quarter
	6		2044	42044	83000						6900		
P4	7	3	2054	42101	82400	250	25K	240	R	1	6900	17	L3 repeated ¼ SW 3Q
	8		2100	4203	83050						8500		
													advance to trace 2 9000 ft.
P5	9	3	2111	42101	82400	250	25K	240	R	2	9000	17	L3 repeated ¼ SW 3Q
	10		2117	42024	83050						7300		
P6		4	2125	4215		006	25K	235	L	2	7300	17	L4N called off
											6500		stopped return to base

STAR 1 SYSTEM

Ft. Custer 20 May 1985	Pro-cess	Gate Delay um Sec	Attn. dB	Ant Elev.	Range RVR	Line	ALT AGL Hundreds of Ft.	GS	Trk	Foot-Age	P.S.	COMMENTS
	04	127	-45	14.1	19	1	320	200	1	0100	.82	
			-43			2		260		1420	1.07	
						3		316		2200	130	
						4		235		2910	.96	
	08	100	-38	8.8	15	1	200	274		3850	113	
			-38			2		213		4420	.88	Glitches on image and
						3		177		5570	.73	test pattern seem to
						4		232		7020	.96	coincides with turbulence
	10	153	-41	6.6	23	1	160	29		9000	105	
	08		-43			2		179		7880	.74	
						3		228		6440	.94	
	07					4		267		5420	1.10	
	06	153		5.0	23	1	120	209		4440	.86	
	08		-42			2		195		1574	.80	
	07		-40			3		226	3	0180	93	
						4		232		1000	96	
Grd Rgn Con Off	C8	153	-41	4.5	23	1	80	187		1500	77	
						2		187		2950	[illegible]	MDA over-heat crash
	07					3		202		4320	84	
	08					4		199		5400	82	
	08		-39		23	1	40	174		6480	72	
	07					2		187		8040	77	Very Turbulent air
	08		-32			3		178		8900	74	
						4		186		7500	75	

20 May	Process	RCR Att.	Ant. Elev.	Near Rng.	Line	ALT AGL	GS	TRK	Tape Footage	P.S.	COMMENTS
	06	-29	4.0	23	1	20	182	4	6200	75	Severe turbulence for system.
	08				2		184		5050	76	
	07				3		178		3400	74	
	06	-27			4		174		2200	73	

STAR 1 **RADAR LOG** DATE: 25 April/85 PAGE 1 OF 1

OPERATOR: A. Leung

	MARK	LINE	GMT TIME	ANT ELEV	RX ATTEN	RMS VIDEO	RTP Swath MOD	RTP Swath SIZE	RTP Swath SUB	LUT INT	LUT STC	GRND CONV	RTP GAIN	RTP LOOKS	COMMENTS
P1	1	1	2010	10.8	38	12	N	full	-	0	0	off	2	4 2345	
P 2	3	2	2023	10.8	38	12	N	full	-	0	0	off	2	4 2345	
P3	5	3	2037	10.8	38	13	N	¼	3	0	0	off	2	4 2345	¼ SW 3Q
P4	7	3	2054	10.8	38	13	N	¼	3	0	0	off	2	4 2345	repeat L3
P5	9	3	2111	10.8	38	13	N	¼	3	0	0	off	2	4 2345	repeat L3
P6	11	4	2125												L4 started but called off

STAR 1 DATA TAPE LOG

Project Number: RB5-146 | Date (DD/MM/YY): 20/05/85 | PILOT:

Project Name: ANTARES | Mission/Flt.No.: | Operator: Cozens

Study Area: Ft. Custer | HDDT No.: HO 124 | Downlink Location: N/A

Mark	Line	GMT Time	Position Lat.	Position Long.	Look Dir. (L/R)	Track (°T)	ALT. AGL (feet)	Grnd. Speed (Kts.)	HD TRK	DT Footage	Range Delay	Paper Speed	COMMENTS
1	1						33K		1	0120			
2										1400			
3										2900			
4										3840			
1	2						20K		1	4400			
2										5570			
3										7010			
4										7900			
1	3						16K		2	9000			
2										7880			
3										6500			
4										5420			
1	4						12K		2	4430			
2										1820			
3										0180			
4									3	1880			

Log Certified By: | Date 20/05/85 | Page 1 of 2

STAR 1 DATA TAPE LOG

Project Number: R85-146
Project Name: Antares
Study Area: Ft. Custer

Date (DD/MM/YY): 20/05/85
Mission/Flt.No.:
HDDT No.: H0124

PILOT:
Operator: Cozens
Downlink Location: N/A

Mark	Line	GMT Time	Position Lat.	Position Long.	Look Dir. (L/R)	Track (°T)	ALT-AGL (feet)	Grnd. Speed (Kts.)	HDDT TRK	HDDT Footage	Range Delay	Paper Speed	COMMENTS
1	5						8K		3	2940			
2										4320			
3										5400			
4										6480			
1	6						4K		3	8020			
2									4	9000			
3										7520			
4										6420			
1	7						2K			5060			
2										3890			
3										2260			

Log Certified By: Date: 20/05/85

APPENDIX C

STAR-1 Ground Station
Softcopy Display
System Specification

5 May 1985

Environmental Research
Institute of Michigan

Ann Arbor, Michigan

TABLE OF CONTENTS

1 SCOPE

This specification establishes the requirements for the development, integration, and testing of a softcopy display system for the Sea-Ice and Terrain Assessment Radar (STAR-1) ground station.

2 APPLICABLE DOCUMENTS

The following documents form a part of this specification.

DRAWINGS:

006-013-SC	STAR-1 Ground Station Parallel Interface Card Schematic

OTHER PUBLICATIONS:

MCS File No.: 8337	INTERA 1.4 MBPS Downlink Operation and Reference Manual

3 REQUIREMENTS

3.1 Definition

The softcopy display system shall consist of hardware and software for supporting real-time acquisition, formatting, display, and exploitation of STAR-1 synthetic aperture radar (SAR) imagery. The display system shall display SAR imagery in real-time with full system image quality, and configured with the necessary operator aids and controls to enhance and exploit the imagery. The display system will be an integral component of the STAR-1 ground station.

3.1.1 Hardware Definition -

The hardware shall include an interface to the STAR-1 ground station, a display controller, a video monitor, and operator interactive input devices.

3.1.1.1 Ground Station Interface -

An interface to the STAR-1 ground station shall be included as part of the display controller. The interface shall provide necessary signal conditioning, buffering, and handshaking to permit continuous real-time acquisition of the imagery by the softcopy display system.

3.1.1.2 Display Controller -

The display controller receives image data via the ground station interface and outputs processed images to the video monitor.

The display controller shall include image acquisition, storage, and display hardware.

3.1.1.2.1 Image Refresh Memory -

Image refresh memory shall store STAR-1 image data.

3.1.1.2.2 Graphics Overlay Memory -

A graphic overlay memory shall support enhancement and exploitation functions.

3.1.1.2.3 Image Archival Memory -

An image archival memory shall support limited image storage and recall capabilities.

3.1.1.2.4 Video Output Signals -

The display controller shall convert STAR-1 SAR image data into video signals for use with a high resolution color video monitor. The video output controller module shall merge image refresh memory, graphics overlay, and alphanumeric overlay data using priority logic and look-up tables to produce a high resolution video signal. The signals shall drive a raster scanned high resolution color video monitor.

3.1.1.3 Video Monitor -

A color video display monitor compatible with the display controller video outputs shall be part of the softcopy display system. The monitor shall provide connections to permit the use of a slave monitor and/or a video hardcopy device.

3.1.1.4 Interactive Input Devices -

A joystick with function keys and a system terminal with a data keyboard and monitor shall support interactive control of display system operation.

3.1.2 Software Definition -

The softcopy display system shall include software to permit operation in two modes: a real-time continuous scrolling display mode, and an image enhancement and exploitation mode. The softcopy display system shall be interactively controlled through keyboard and joystick inputs.

3.1.2.1 Real-time Continuous Scrolling Mode -

The softcopy display system shall support a real-time continuous scrolling display mode. In this mode, a subset of image data is stored into image refresh memory.

3.1.2.1.1 Image Swath Selection -

Image swath selection software shall select a partial STAR-1 image swath for storage into image refresh memory. Operator controls shall interactiveley specify swath selection areas. A subswath selection indicator shall also show swath the beginning and ending pixel location (possible). The joystick shall increment or decrement the pixel location values and the displayed subswath shall change accordingly (possible). The status display shall be viewable by operator request. The image swath selection parameters shall remain in effect until explicitly changed by the operator.

3.1.2.1.2 Scrolling Direction -

Scrolling direction software shall control image scrolling direction on the video monitor. The scrolling shall be in either the top-to-bottom, or bottom-to-top direction.

3.1.2.2 Image Enhancement And Exploitation Mode -

Image enhancement functions shall perform image roam, zoom, and intensity transformation functions. Exploitation aids shall perform image annotation and archival, image recall, and image mensuration functions.

3.1.2.2.1 Roam/Zoom Function -

The roam and zoom function shall allow roaming and zooming through the contents of image refresh memory. The operator shall have control over the displayed scene by interactively

adjusting image zoom factors and by using a joystick to roam through the image.

3.1.2.2.2 Intensity Transformation Functions -

Intensity transformation functions shall enhance imagery through performance of piecewise linear, thresholding, and intensity inversion.

3.1.2.2.3 Image Archival And Recall Function -

The image archival function shall store the contents of image refresh memory. The recall function shall restore the image refresh memory contents. The function shall allow annotation of imagery before archival.

3.1.2.2.4 Mensuration Function -

The mensuration function shall measure the distance between displayed image picture elements. Interactive controls shall identify pixel locations. The software shall compute and display the distance between the specified locations.

3.2 Performance Characteristics

Performance characteristics are defined for each paragraph within section 3.1. Each definition paragraph has a corresponding characteristic paragraph.

3.2.1 Hardware Characteristics -

Hardware shall support all software operations required in support of the real-time scrolling display, image enhancement, and exploitation functions.

3.2.1.1 Ground Station Interface -

The ground station interface shall consist of an AYDIN developed board which shall interface the STAR-1 ground station to the parallel interface within the display controller. AYDIN shall build an interface cable of length 25 feet. The interface board shall reside within the display controller. The interface requirements are defined in the applicable documents section 2.0.

3.2.1.2 Display Controller -

The display controller shall be an AYDIN Model 5216.

3.2.1.2.1 Image Refresh Memory -

Image refresh memory shall store image data. The image memory shall have sufficient capacity to store 1024 lines of image data, each line consisting of 1024 8-bit samples. Each image refresh memory line shall be accessable to support the continuous scrolling display.

3.2.1.2.2 Graphics Overlay Memory -

A graphics overlay memory shall store graphical information. The graphics memory shall be 1024 lines by 1024 horizontal elements. Each accessable element shall be at least 1 bit. Graphics overlay pixels of value "1" shall be displayed as a bright white point. Graphics overlay pixels of value "0" shall be transparent and not obscure underlying image pixels. The graphics memory shall be independant of image refresh memory for scroll and zoom operations. The graphics overlay shall have display precedence over the image refresh

memory.

3.2.1.2.3 Image Archival Memory -

A disk system shall store 20 images and associated annotation. Each archived image shall consist of 1024 lines of 1024 8-bit image data and up to 10 annotation entries.

3.2.1.2.4 Video Output Signals -

The display controller shall generate video output signals for use with the raster scanned high-resolution color video monitor. The signals shall consist of 1024 visible video lines of 1024 horizontal elements. Look-up tables shall be used for image data intensity transformations. The look-up tables shall accept 8-bit image data from image refresh memory and produce 8 bits each of red, green, and blue data.

3.2.1.3 Video Monitor -

The monitor shall be at least 19" as measured diagonally with an actual viewing area of 15" wide by 11" high. The display monitor shall be underscanned to permit viewing of all screen addressable pixels. The display monitor dot pitch shall be 0.31mm or less. The scanning electron beam shall be aproximately twice the dot pitch as measured at the 50% spot illumination levels. A suitable CRT phosphor shall be used to provide for flicker free operation without "ghosting" effects during continuous scrolling operation.

Monitor misconvergence shall be limited to one-third of spot size within an area defined by a circle inscribed on the display surface with a diameter equal to the CRT screen height. Misconvergence shall be limited to approximately 80% of spot size elsewhere. No spot shall deviate from its proper position by more than 2 % of raster height. Video amplifiers shall have sufficient bandwidth to limit pixel rise time to less than one-third of the total pixel time.

The monitor shall have manual CRT brightness and contrast controls, and a manual degaussing switch. The monitor shall use an in-line gun to minimize de-gaussing problems (possible).

3.2.1.4 Interactive Input Devices -

Interactive input devices shall support interactive use of the display system. A data keyboard shall be the primary source of operator input. The keyboard character set shall include keys for all the displayable ASCII character set.

The system terminal display shall contain at least 24 lines of 80 characters per line. The characters set shall include all displayable ASCII characters. Characters shall be displayed as bright white or other color on a black background. The system terminal shall communicate with the display controller over an RS-232 serial communications line.

A joystick shall support interactive image enhancement and exploitation functions. Joystick movement shall move cursor locations during mensuration, roam and zoom, and intensity transformation functions. Joystick movement shall result in updated joystick position registers that can drive cursors. A function key shall cause cursor location sampling (possible).

3.2.2 Software Characteristics -

Software shall respond to interactive operator requests and control display controller hardware device registers and memories to produce a real-time scrolling display, and perform image enhancement and exploitation functions. The operating modes shall be entered from any other mode under operator request. The initial operating mode shall be the continuous scrolling mode. Operator selectable parameters shall be saved when changing modes and be restored when the interrupted mode is reactivated.

Software shall be designed modularly to ensure reliable operation and to permit future expansion.

3.2.2.1 Real-time Continuous Scrolling Mode -

The scrolling operation shall be performed at a sufficient rate to ensure no loss of data.

3.2.2.1.1 Image Swath Selection -

Image swath selection software shall select a subset of the incoming image data for transfer into image refresh memory.

3.2.2.1.2 Scrolling Direction -

The displayed image shall appear to scroll from top-to-bottom or from bottom-to-top. The scrolling direction shall be under operator control and shall remain in effect for the continuous scrolling display mode until explicitly altered by the operator. The scrolling direction shall be operator controlled through function switches or command menus.

3.2.2.2 Image Enhancement And Exploitation Mode -

An image enhancement and exploitation function menu shall be displayed when this mode is selected. The image refresh memory shall remain unchanged during this mode.

3.2.2.2.1 Roam/Zoom Function -

The roam function shall view the entire contents of a 1024 line by 1024 element image refresh memory. The zoom function shall be implemented by hardware pixel replication. Image roam shall be controlled by joystick movement. Image zoom shall be controlled by function switches. One function switch shall cause image magnification (zoom) by a factor of two. The other function switch shall cause image demagnification by a factor of two. The zoom factors shall range from 1 to 16. Roam and zoom functions shall not alter the contents of image memory, or change the appearance alphanumeric overlays.

3.2.2.2.2 Intensity Transformation Functions -

The operator shall specify the type of transformation function and applicable transformation function parameters. All transformations shall produce black and white output imagery from the image memory data. The operator shall enable or disable look-up tables (return to linear mapping). Transformation functions shall be implemented using video look-up tables. The look-up table settings shall remain in effect during the continuous scrolling mode, and enhancement and exploitation mode. The use of intensity transformations shall not alter the contents of image refresh memory.

3.2.2.2.2.1 Piecewise Linear Transformation -

The piecewise lineary transformation shall be implemented according the the following equations.

Input - 8 bit image intensity
$0 <= Input <= 255$

Output - 8 bit remapped black and white video output
0<=Output<=255

0=Black
255=White

BreakPoint - Transition point between two
linear mapping functions
0<=BreakX<=255
0<=BreakY<=255

Region 1 - Input < BreakX
Output= (BreakY/BreakX) * Input

Region 2 - Input >= BreakX
Output = ((255-BreakY)/(255-BreakX)) * (Input-BreakX)
+ BreakY

3.2.2.2.2.2 Thresholding Transformation -

The thresholding transformation shall be implemented according the the following equations.

Input - 8 bit image intensity
0<=Input<=255

Output - 8 bit remapped black and white video output
0<=Output<=255

0=Black
255=White

Threshold - 8 bit intensity threshold value
0<=Threshold<=255

Output = 0 for input < Threshold
Output = Input for input >= Threshold

3.2.2.2.2.3 Intensity Inversion Transformation -

The intensity inversion transformation shall be implemented according to the following equation.

Input - 8 bit image intensity
0<=Input<=255

Output - 8 bit remapped black and white video output
0<=Output<=255

0=Black
255=White

Output = 255-Input

3.2.2.2.3 Image Archival And Recall Function -

The image archival and recall function shall store the image refresh memory onto a non-volatile storage device. Archived imagery shall be referenced by a unique image number. The image number shall be specified by the operator. The operator shall have the option to annotate archived imagery. Upon recall, the imagery shall reappear on the image monitor. The annotations shall appear on the data terminal. The annotations shall be archived with its associated image but shall not overwrite any image data.

3.2.2.2.4 Mensuration Function -

Mensuration software shall measure the distance between two operator specified image points. The point coordinates shall be specified as display screen coordinates by placing a cursor over the desired location. The display coordinate shall be transformed to image refresh memory coordinates by compensating for image zoom factors and the image swath element increment. The distance between the selected points shall then be be displayed in pixel units on the monitor.

3.3 Design And Construction

The display system will be installed in a stationary van or truck. Provisions shall be made for securing the display system components during vehicle movements (e.g., lock disk head assembly). System operation is not required while the vehicle is moving.

3.4 Documentation

AYDIN shall provide an operating manual describing the softcopy display system operation, operator controlled functions, and diagnostic messages. Source listings of non-proprietary software shall be delivered to EPIM.

3.5 Personnel And Training

AYDIN shall train personnel from ERIM on the operation of the softcopy display system.

3.6 Physical Conditions

The display system shall function under the following conditions.

Power	60 Hz; 115 VAC; 30 Amps
Temperature	10 to 45 deg. C, operating -25 to 85 deg. C, nonoperating
Humidity	10 to 95 %, no condensation
Altitude	0 to 10,000 feet, operating 0 to 50,000 feet, nonoperating

3.7 Maintenance

AYDIN shall be responsible for hardware and software maintenance as specified in the contract.

3.8 Precedence

In the event of conflicting requirements between this specification and other documents, this specification shall supercede. AYDIN shall notify ERIM of conflicting requirements.

4 QUALITY ASSURANCE PROVISIONS

4.1 Objective

The objective of this section is to specify provisions for determining compliance of the softcopy display system to the requirements of section 3. Verification shall be performed on the integrated (hardware and software) softcopy display system.

4.2 General

ERIM will provide a replay unit consisting of a high density digital tape recorder, playback electronics, and parallel output port to aid in display system development and testing. This replay unit shall be used as a STAR-1 data source during display system testing. Proper softcopy display system operation with the replay unit shall be verified by ERIM before display system acceptance.

4.3 Responsibility For Quality Assurance

Unless otherwise specified in the contract, AYDIN shall be responsible for the performance of all quality assurance requirements as specified. ERIM reserves the right to perform any of the verifications in the specification where such verifications are deemed necessary to assure that the softcopy display system conforms to the requirements.

4.4 Verification Tests

The verification tests shall consist of a verification of softcopy display system operation under specific conditions to verify the performance characteristics as defined in section 3.2. The replay unit shall be used as a STAR-1 data source for all verfication tests. ERIM shall observe verification tests.

5 NOTES

5.1 STAR-1 Radar System Description

The Sea-Ice and Terrain Assesment Radar (STAR-1) was developed by the Environmental Research Institute of Michigan (ERIM) and INTERA Environmental Consultants, Ltd. The STAR-1 radar is a fully focused sidelooking system capable of mapping from either side of the aircraft. The STAR-1 is capable of operating in either a wide swath mode which produces imagery covering 45 Km, or high resolution mode which produces imagery covering 23 Km. Imagery is processed in real-time by a dedicated SAR signal processing system installed onboard the aircraft. The imagery produced by the STAR-1 system is recorded by onboard recording systems, and also telemetered to a STAR-1 ground station.

5.2 Intended Use

The availability of real-time synthetic aperture radar (SAR) image formation capabilities provided by the STAR-1 radar system introduces the need for an advanced ground-based image display station. This display station is envisioned as a state-of-the-art hardware and software system capable of displaying SAR imagery in real-time while preserving full system image quality, and configured with the necessary operator aids and controls to enhance and exploit SAR imagery. This display system will be an integral component of the STAR-1 ground station and will be used during STAR-1 data collections.

Presently, STAR-1 real-time image display capabilities are limited to a low quality heat processed dry silver paper hardcopy, or a higher quality wet chemically processed photographic film hardcopy. Both hardcopy media are useful for basic system operational assessment and extraction of gross image features. However, neither paper nor film hardcopy preserve full image quality, nor are they in suitable formats for subsequent image exploitation. A more capable real-time SAR image display system is needed that will :

- o Provide a continuously updated scrolling real-time display with operator control over viewable area and scene orientation;
- o Preserve full image quality in both dynamic range and spatial resolution;
- o Provide a freeze frame display for detailed interpreter analysis and exploitation concurrent with the continuously scrolled display;

- o Provide processing enhancements to aid the interpreter in target detection and identification;
- o Provide image archival capabilities for image storage and recall;
- o Provide capabilities to permit operator image annotation, event recording, image to ground coordinate calculation, and coordinate overlays;
- o Provide expansion capabilities for integration of other sensor data within a single display such as aircraft positioning overlays, Moving Target Indicator (MTI), or Remotely Piloted Vehicle (RPV) video;
- o Provide diagnostic capabilites to assess SAR image quality, and detect and identify failed display station system components; and
- o Be lightweight, compact, rugged, and reliable.

SUBSWATH SELECTION

An arbitrary subset of equally spaced pixels from STAR-1 image lines shall be loaded into image refresh memory. For example, if image refresh memory consists of 1024 pixels per line, then extract a 1024 horizontal pixel subset of the image line.

The operator shall specify the subswath by entering the starting image pixel index corresponding to the starting image refresh memory element index (left hand side of screen). An increment between successive pixels shall define adjacent image refresh memory elements. By properly setting the starting index and element increments, the operator shall control image scene centering, image resolution (by skipping), and image orientation.

Starting element indices shall range from 1 through 4096 inclusive. Element increments shall range from -4 to +4 inclusive. However, an element increment of 0 shall not be permitted. Sufficient validation logic shall ensure a consistant set of parameters so that the selected subswath will fill image refresh memory. Typical valid parameters are presented below.

Example 1 - Select a subswath corresponding to the middle of the full image swath at full resolution, and same horizontal orientation. Image refresh memory is 2048 pixels wide

Element starting index = 1736
Element increment = 1
Element ending index = 3783 (computed)

Example 2 - Select the middle of image swath at full image resolution, reflect image lines in horizontal direction

Element starting index = 3783
Element increment = -1
Element ending index = 1736 (computed)

Example 3 - Select left hand side of image at 1/2 resolution, reflect image lines in horizontal direction

Element starting index = 4096
Element increment = -2
Element ending index = 2 (computed)

The subswath control parameters can be clarified through the following section of pseudo-code describing the image memory loading process for one line.

```
!  REFRESHMEM = refresh memory array
!  NPIXH = Number of horizontal pixels in image refresh memory
!  STARTDATA = Array containing one 4096 pixel line
!  START = Starting element index
!  INC = Increment between successive image samples

      K=START
      FOR I=1 to NPIXH
         REFRESHMEM(I,LINE)=STARTDATA(K)
         K=K+INC
      END.
```

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